Chapter 8

Principles and Problems of Vision

Aircrew members rely more on the visual sense than any other sense to orient themselves in flight. The following visual factors contribute to aviation performance: good depth perception for safe landings, good visual acuity to identify terrain features and obstacles in the flight path, and good color vision. Although vision is the most accurate and reliable sense, visual cues can be misleading, contributing to incidents occurring within the flight environment. Aviation personnel must be aware of and know how to compensate effectively for the following: physical deficiency or self-imposed stress, such as smoking, which limits night-vision capability; visual-cue deficiencies; visual limitations, consisting of degraded visual acuity, dark adaptation, and color and depth perception. For example, at night, the unaided eye has degraded visual acuity. To complete the mission safely, aircrew members must learn and effectively apply proper night-vision viewing techniques to compensate for this limitation.

VISUAL DEFICIENCIES

8-1. One contributing factor associated in achieving safe and successful flights is that aviation personnel must be able to recognize and understand common visual deficiencies. Important eye problems related to degraded visual acuity and depth perception include myopia, hyperopia, astigmatism, presbyopia, and retinal rivalry. Surgical procedures to sculpt or reshape the cornea may also result in visual deficiencies.

MYOPIA

8-2. This condition, often referred to as nearsightedness, is caused by an error in refraction in which the lens of the eye does not focus an image directly on the retina. When a myopic person views an image at a distance, the actual focal point of the eye is in front of the retinal plane (wall), causing blurred vision. Thus, distant objects are not seen clearly; only nearby objects are in focus. Figure 8-1 depicts this condition.

NIGHT MYOPIA

8-3. At night, blue wavelengths of light prevail in the visible portion of the spectrum. Therefore, slightly nearsighted (myopic) individuals viewing blue-green light at night may experience blurred vision. Even aircrew members with perfect vision will find that image sharpness decreases as pupil diameter increases. For individuals with mild refractive errors, these factors combine to make vision unacceptably blurred unless they wear corrective glasses.

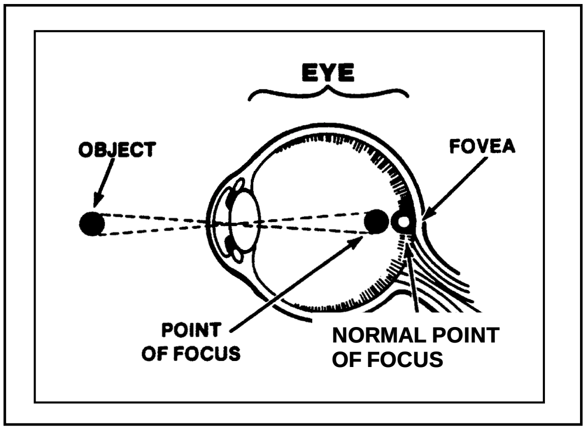

Figure 8-1. Myopia (Nearsightedness)

8-4. Another factor to consider is "dark focus." When light levels decrease, the focusing mechanism of the eye may move toward a resting position and make the eye more myopic. These factors become important when aircrew members rely on terrain features during unaided night flights. Special corrective lenses can be prescribed to correct for night myopia.

HYPEROPIA

8-5. Hyperopia is also caused by an error in refraction—the lens of the eye does not focus an image directly on the retina. In a hyperopic state, when an aircrew member views a near image, the actual focal point of the eye is behind the retinal plane (wall), causing blurred vision. Objects that are nearby are not seen clearly; only more distant objects are in focus. This problem, referred to as farsightedness, is shown in Figure 8-2.

ASTIGMATISM

8-6. An unequal curvature of the cornea or lens of the eye causes this condition. A ray of light is spread over a diffuse area in one meridian. In normal vision, a ray of light is sharply focused on the retina. Astigmatism is the inability to focus different meridians simultaneously. If, for example, astigmatic individuals focus on power poles (vertical), the wires (horizontal) will be out of focus for most of them, as shown in Figure 8-3.

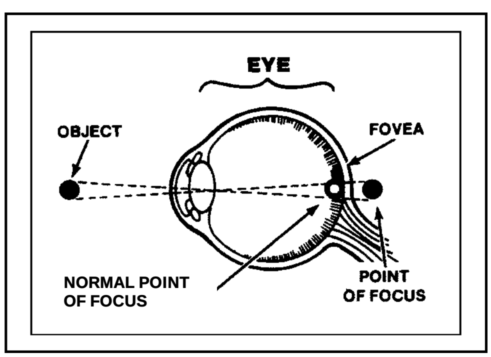

Figure 8-2. Hyperopia (Farsightedness)

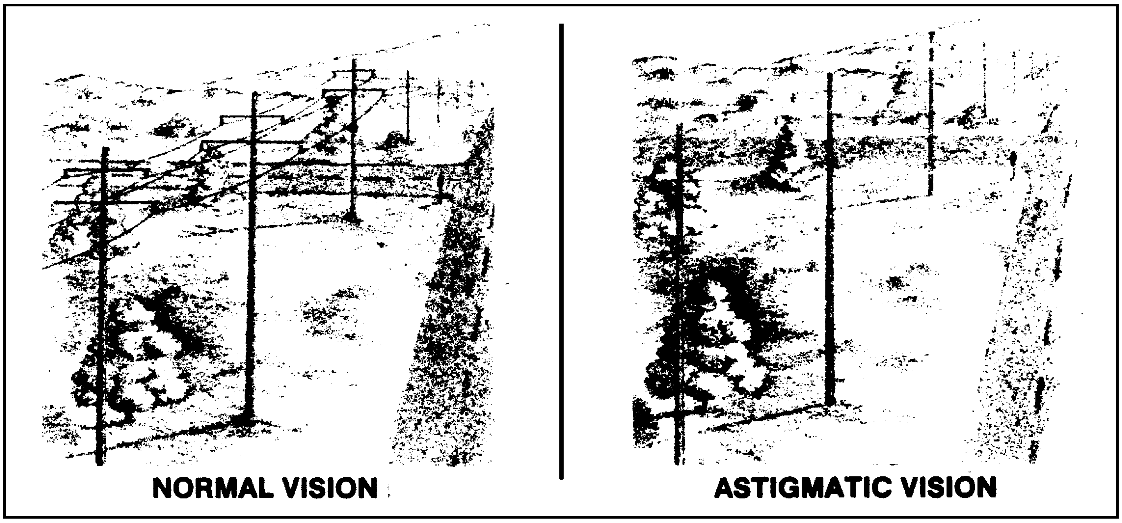

Figure 8-3. Astigmatism

PRESBYOPIA

8-7. This condition is part of the normal aging process, which causes the lens to harden. Beginning in their early teens, the human eye gradually loses the ability to accommodate for and focus on nearby objects. When people are about 40 years old, their eyes are unable to focus at normal reading distances without reading glasses. Reduced illumination interferes with focus depth and accommodation ability. Hardening of the lens may also result in clouding of the lens (cataract formation). Aviators with early cataracts may see a standard eye chart clearly under normal daylight but have difficulty seeing under bright light conditions. This problem is due to the light scattering as it enters the eye. This glare sensitivity is disabling under certain circumstances. Glare disability, related to contrast sensitivity, is the ability to detect objects against varying shades of backgrounds. Other visual functions decline with age and affect the aircrew member's performance:

- Dynamic acuity.
- Recovery from glare.
- Function under low illumination.
- Information processing.

RETINAL RIVALRY

8-8. Eyes may experience this problem when attempting to simultaneously perceive two dissimilar objects independently. This phenomenon may occur when pilots view objects through the heads-up display in the AH-64 Apache. If one eye views one image while the other eye views another, conflict arises in total perception. Quite often, the dominant eye will override the nondominant eye, possibly causing the information delivered to the nondominant eye to be missed. Additionally, this rivalry may lead to ciliary spasms and eye pain. Mental conditioning and practice appear to alleviate this condition; therefore, retinal rivalry becomes less of a problem as aircrew members gain experience.

SURGICAL PROCEDURES

Radial Keratotomy

8-9. Radial keratotomy is a surgical procedure that creates multiple radial, lased, spokelike incisions through the use of an argon laser upon the cornea of the eye to improve visual acuity. Radial keratotomy permanently disqualifies an individual from flight for Army aviation. The resulting glare sensitivity (sparkling effect throughout the viewing field) and tissue scarring contribute to flight disqualification.

Photorefractive Keratectomy

8-10. PRK is a procedure to correct corneal refractive errors by use of a laser. The laser has replaced the scalpel in surgical correction of myopia. PRK ablates or reshapes the central cornea. The effects of this procedure flatten the cornea, which bends or refracts the light properly on the retina, correcting the myopic deficiency. This procedure is currently being considered for approval but, at this time, like radial keratotomy, permanently disqualifies an individual from flight duty for Army aviation. Irregularity of the cornea surface causes astigmatism, the most common cause of disqualification.

LASIK or Keratomileusis

8-11. LASIK is the procedure used to carve and reshape the cornea. Surgeons use a laser to shave the anterior half of the cornea, creating a flap. The flap is retracted, and the inner side of the cornea is reshaped with a laser, causing the cornea to flatten. When the reshaping is completed, the flap is replaced in its original position and sutured (sewn) back into place, similar to a Band-Aid® effect. The flatter cornea now bends or refracts the light properly on the retina. Unlike radial keratotomy or PRK, this technique can correct for severe myopia and hyperopia. The main adverse effect is irregularity of the corneal surface, causing astigmatism. In addition, if the flap of an individual who has undergone this procedure became suddenly unattached in an accident, the result would be a permanent defect to the cornea and severely degraded visual acuity. This procedure permanently disqualifies the aircrew member from flight duty for Army aviation.

8-12. Various surgical procedures are available to correct visual deficiencies; not all are listed. The procedures described above are currently the most common. AR 40-501 and AR 95-1 state that all corrective eye surgeries involving LASIK or PRK or other forms of corrective eye surgery disqualify Army aircrew members from flight duty. Aircrew members must consult their flight surgeons before undergoing these procedures.

ANATOMY AND PHYSIOLOGY OF THE EYE

8-13. Aircrew members are required to understand basic anatomy and physiology of the eye if they are to use their eyes effectively during flight. Figure 8-4 shows the basic anatomy of the human eye.

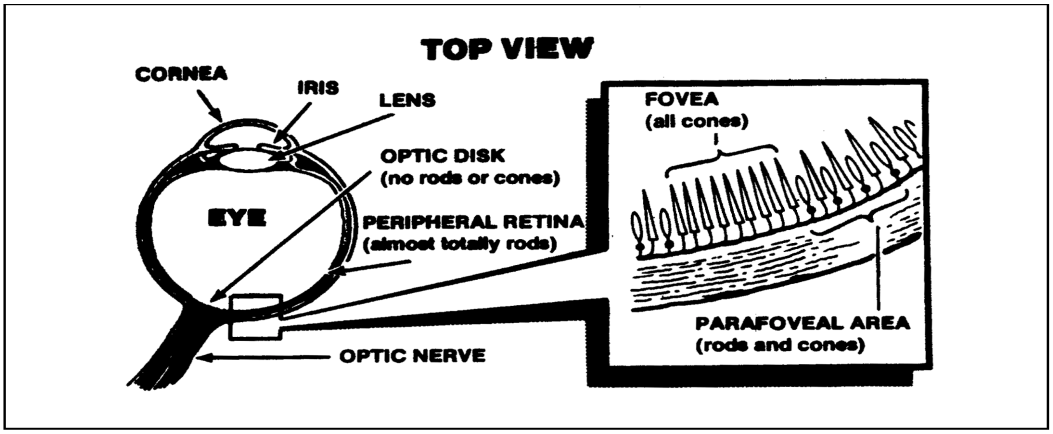

Figure 8-4. Anatomy of the Eye

VISUAL ACUITY

8-14. Visual acuity measures the eye's ability to resolve spatial detail. The Snellen visual acuity test is commonly used to measure an individual's visual acuity. The Snellen test expresses the comparison of the distance at which a given set of letters is correctly read to the distance at which the letters would be read by someone with clinically normal eyesight. Normal visual acuity is 20/20. A value of 20/80 indicates that an individual reads at 20 feet the letters that an individual with normal acuity (20/20) reads at 80 feet away. The human eye functions like a camera. It has an instantaneous field of view, which is oval and typically measures 120 degrees vertically by 150 degrees horizontally. When two eyes are used for viewing, the overall FOV measures about 120 degrees vertically by 200 degrees horizontally.

ANATOMY AND PHYSIOLOGY

8-15. When light from an object enters the eye, it passes through the cornea. The cornea is a circular, transparent protective tissue that projects forward and protects the eye. Once light travels through the cornea, it enters the pupil. The pupil is the opening (black center portion) in the center of the iris. The pupil allows the light to enter the eye to stimulate the retina. The iris is the round, pigmented (colored) membrane of the eye surrounding the pupil. For example, for people with brown, green, or hazel eyes, that colored portion is the iris. The iris adjusts the size of the pupil by using its ciliary muscles, which are attached to the pupil. The iris adjusts the size of the pupil to regulate the amount of light entering the eye. When the pupil dilates (enlarges) under low light levels, it allows more light to enter the eye to further stimulate the retina. When the pupil constricts (becomes smaller) under high light levels, it decreases the amount of light entering the eye, avoiding oversaturation (stimulation) of the retina. Light entering the eye is regulated so that the retina is not undersaturated or oversaturated with light images, which would negatively affect visual acuity. Once the light travels through the pupil, it will strike the lens. The lens is a transparent, biconvex membrane located behind the pupil. The lens then directs (refracts) the light upon the retina (the posterior or rear portion of the eye). The retina is a complex, structured membrane, consisting of 10 layers called the Jacob's membrane. The retina contains many tiny photoreceptor cells, called rods and cones. Once light stimulates the retina, it produces a chemical change within the photoreceptor cells. When the chemical change occurs, nerve impulses are stimulated and transmitted to the brain via the optic nerve. The brain deciphers the impulse and creates a mental image that interprets what the individual is viewing.

RETINAL PHOTORECEPTOR CELLS

8-16. **Rods and Cones.** The retinal rod and cone cells are so named because of their shape. The cone cells are used principally for day or high-intensity light vision (viewing periods or conditions). The rods are used for night or low-intensity light vision (viewing periods or conditions). Some of the characteristics of day and night vision are due to the distribution pattern of rods and cones on the retina. The center of the retina, the fovea, contains a very high concentration of cone cells but no rod cells. The concentration of rod cells begins to increase toward the periphery of the retina.

8-17. **Cone Neurology.** The retina contains seven million cone cells. Each cone cell in the fovea is connected to a single nerve fiber that leads directly to the brain. This single-nerve connection of each foveal cone to the brain means that each cone generates a nerve impulse under sufficient light levels. This occurs during daylight or viewing conditions of high-intensity light exposure. Cone cells provide sharp visual acuity and the perception of color. When crew members view under low light or dark conditions, cone cells depict shades of black, gray, and white; crew members will perceive other colors if the light intensity is heightened by artificial light sources:

- Aircraft position lights.
- Anticollision lights.
- Runway lights.
- Beacon lights.
- Artificial lighting related to metropolitan areas.

8-18. **Rod Neurology.** There are 120 million rod cells in the retina. Rod cells have a 10-to-1, up to a 10,000-to-1, ratio of rod cells to neuron cells within the retina. Because of the large number of rod cells that are connected to each nerve fiber outside of the fovea, dim light can trigger a nerve impulse to the brain. The periphery of the retina, where the rods are concentrated, is much more sensitive to light than is the fovea. This concentration of rods is responsible for night vision (peripheral vision), which provides for silhouette recognition of objects. This is also why aircrew members' eyes are highly sensitive to light when viewing during low ambient light or dark conditions.

IODOPSIN AND RHODOPSIN

8-19. Vision is possible because of chemical reactions within the eye. The chemical iodopsin is always present within the cone cells. Iodopsin permits the cone cells to respond immediately to visual stimulation, regardless of the level of ambient light. However, rod cells contain an extremely light-sensitive chemical called rhodopsin, more commonly referred to as visual purple. Rhodopsin is not always present in the rods because light bleaches it out and renders the rods inactive to stimulation. So sensitive is rhodopsin that bright-light exposure can bleach out all visual purple within seconds.

Night Vision

8-20. For night vision to take place, rhodopsin must build up in the rods. The average time required to gain the greatest sensitivity is 30 to 45 minutes in a dark environment. When fully sensitized (dark adapted), the rod cells may become up to 10,000 times more sensitive than at the start of the dark adaptation period. Through a dilated pupil, total light sensitivity may increase 100,000 times.

Day Blind Spot

8-21. Because humans have two eyes and view all images with binocular vision, each eye compensates for the day blind spot in the optic disk of the opposite eye. The day blind spot covers an area of 5.5 to 7.5 degrees. It is located about 15 degrees from the fovea and originates where the optic nerve attaches to the retina. The size of the day blind spot is due to the oval shape of the optic nerve combined with its offset position where it attaches to the retina by the 5.5 to 7.5 degrees. Where the optic nerve attaches to the retina, no photoreceptor cells (cones or rods) are present. The day blind spot only causes difficulty when individuals do not move their head or eyes but continue to look straightforward while an object is being brought into the visual field. Figure 8-5 demonstrates the presence of the day blind spot.

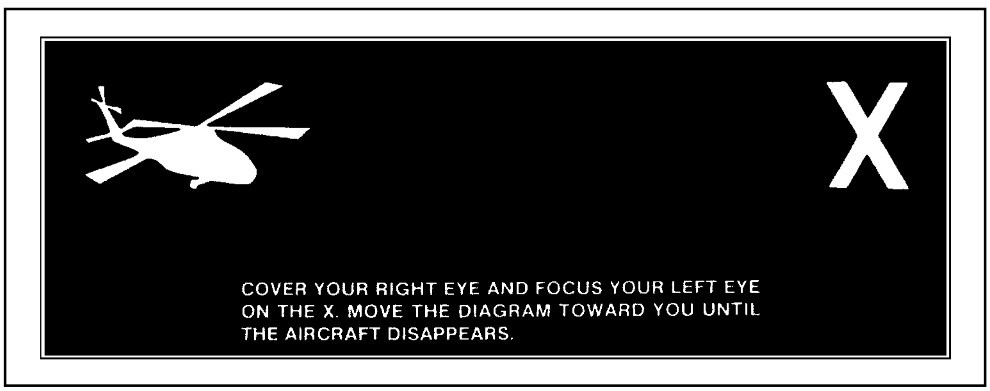

Figure 8-5. Demonstration of the Day Blind Spot

TYPES OF VISION

8-22. The three types of vision (viewing periods) associated with Army aviation are photopic, mesopic, and scotopic. Each type (viewing period) requires different sensory stimuli or ambient light conditions.

PHOTOPIC VISION

8-23. Photopic vision, shown in Figure 8-6, is experienced during daylight or under high levels of artificial illumination. The cones concentrated in the fovea centralis are primarily responsible for vision in bright light. Because of the high-level light condition, rod cells are bleached out and become less effective. Sharp image interpretation and color vision are characteristics of photopic vision. The fovea centralis is automatically directed toward an object by a visual fixation reflex. Therefore, under photopic conditions, the eye uses central vision for interpretation, especially for determining details.

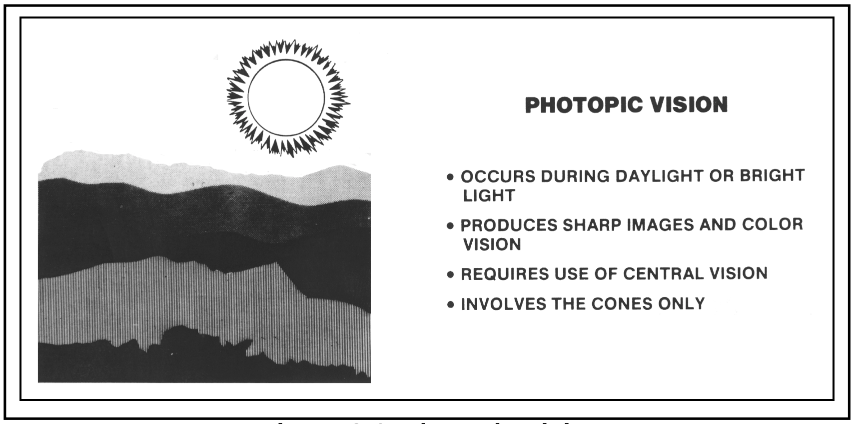

Figure 8-6. Photopic Vision

MESOPIC VISION

8-24. Mesopic vision, shown in Figure 8-7, is experienced at dawn and dusk and under full moonlight. Vision is achieved by a combination of rods and cones. Visual acuity steadily decreases with declining light. Color vision is reduced (degraded) as the light level decreases, and the cones become less effective. Mesopic vision (viewing period) is the most dangerous of all three types of vision for aircrew members. How degraded the ambient light condition is during this type of vision will determine what type of scanning (viewing) technique that aircrew members should use to detect objects and maintain a safe and incident-free flight. For example, with the gradual loss of cone sensitivity, off-center viewing may be necessary to detect objects in and around the flight path. If aircrew members fail to recognize the need to change scanning techniques from central or focal viewing to off-center viewing, incidents may occur.

SCOTOPIC VISION

8-25. Scotopic vision, shown in Figure 8-8, is experienced under low-light level environments such as partial moonlight and starlight conditions. Cones become ineffective, causing poor resolution of detail. Visual acuity decreases to 20/200 or less, and color perception is lost. A central blind spot (night blind spot) occurs when cone-cell sensitivity is lost. Primary color perception during scotopic vision is shades of black, gray, and white unless the light source is high enough in intensity to stimulate the cones. Peripheral vision is primary for viewing with scotopic vision.

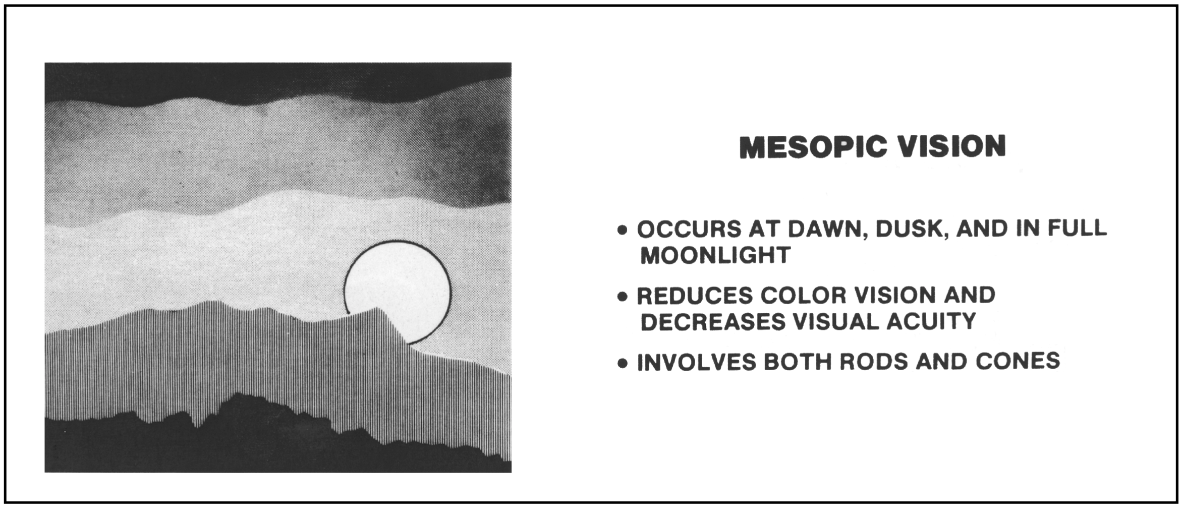

Figure 8-7. Mesopic Vision

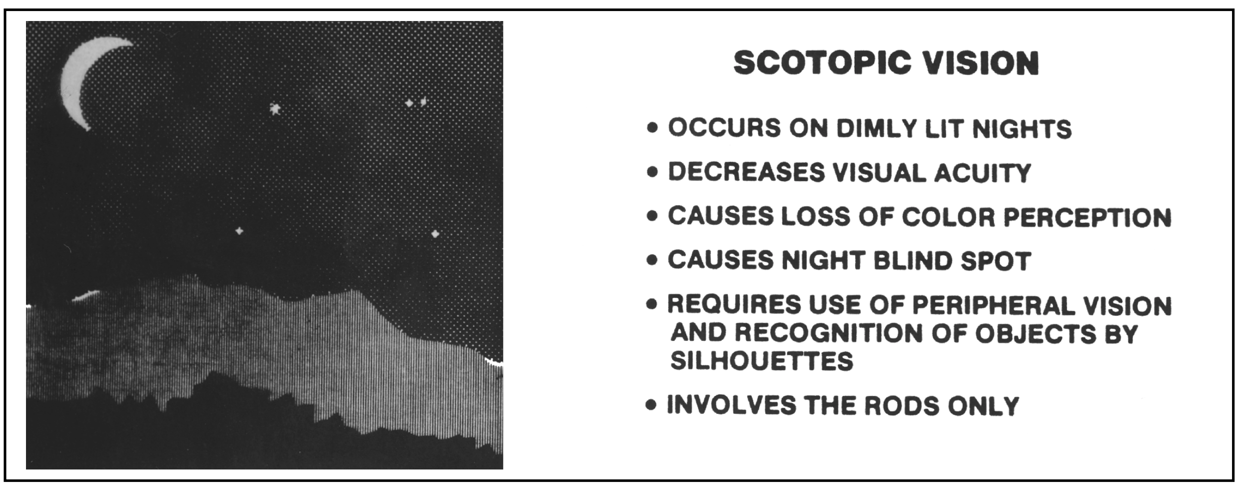

Figure 8-8. Scotopic Vision

Night Blind Spot

8-26. The night blind spot, shown in Figure 8-9, should not be confused with the day blind spot. The night blind spot occurs when the fovea becomes inactive under low-level light conditions. The night blind spot involves an area from 5 to 10 degrees wide in the center of the visual field. If an object is viewed directly at night, it may not be seen because of the night blind spot; if the object is detected, it will fade away when stared at for longer than two seconds. The size of the night blind spot increases as the distance between the eyes and the object increases. Therefore, the night blind spot can hide larger objects as the distance between the observer and the object increases. Figure 8-10 shows this effect.

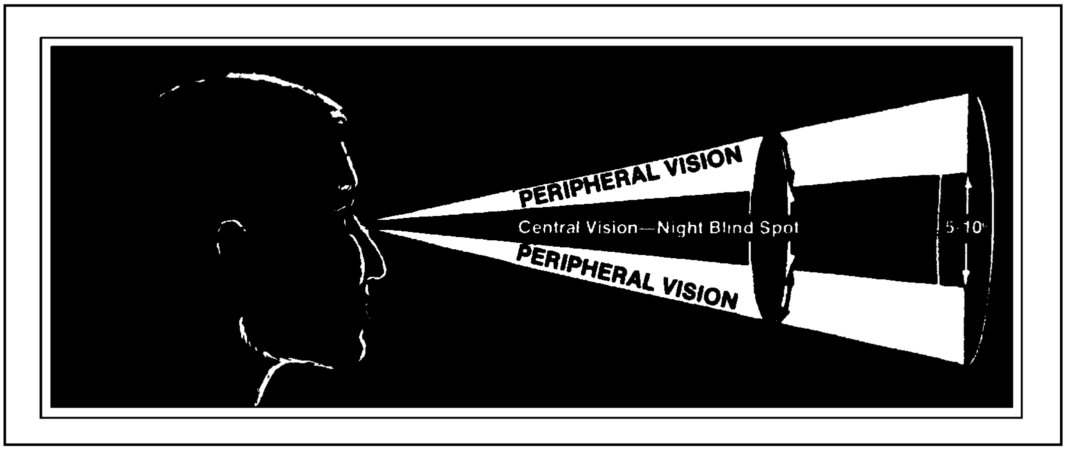

Figure 8-9. Night Blind Spot

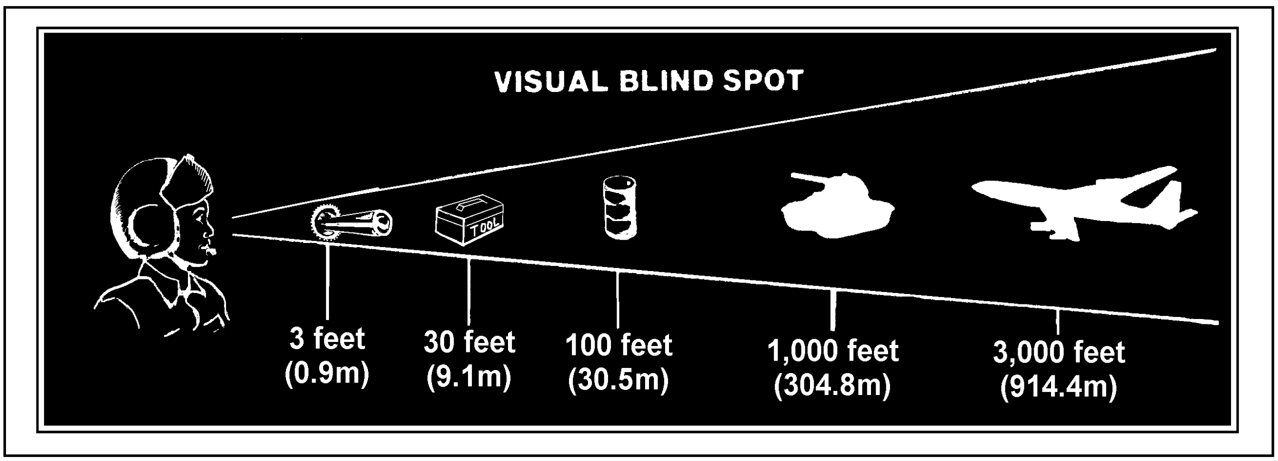

Figure 8-10. Effects of the Night Blind Spot

Peripheral Vision

8-27. Stimulation of only rod cells (peripheral vision) is primary for viewing during scotopic vision. Aircrew members must use peripheral vision to overcome the effects of scotopic vision. Peripheral vision enables aircrew members to see dimly lit objects and maintain visual reference to moving objects. The natural reflex of looking directly at an object must be reoriented through night-vision training. To compensate for scotopic vision, aircrew members must use searching eye movements to locate an object and small eye movements to retain sight of the object. Aircrew members must use off-center viewing. Characteristically, if the eyes are held stationary when focusing on an object for more than two to three seconds using scotopic vision, an image may fade away (bleach out) completely.

FACTORS AFFECTING OBJECT VISIBILITY

8-28. The ease with which an object can be seen depends on various factors. Each factor can either increase or decrease the visibility of an object. The visibility of an object increases as the—

- Angular size of the object increases as the distance between the object and the viewer decreases.
- Illumination (overall brightness) of ambient light increases.
- Degree of retinal adaptation increases.
- Color and contrast between the target and background increase.
- Position of the target within the visual field (visibility threshold) increases.
- The focus of the eye and length of time viewing the object increase.
- Atmospheric clarity increases. ND-15 sunglasses can aid visibility during viewing conditions of excessive light or brightness.

8-29. As aircraft speed increases, there is interference in the perception of instantaneous visual pictures. In some cases, it may take one to two seconds or longer to recognize and consciously assess a complex situation. By the time that an object is eventually perceived, it may have already been overtaken. The time that it takes to perceive an object becomes significant to the aircrew member. Perception time includes the time that it takes—

- The message indicating that an image of an object has been identified within the visual field and that image information travels from the eye to the brain to include the time it takes the brain to receive, comprehend, and identify the information.
- The eye to turn toward and focus on the unknown object.
- An individual to recognize the object and determine its importance.
- To transmit a decision to move muscles and cause the aircraft to respond to control inputs.

DARK ADAPTATION

8-30. Dark adaptation is the process by which the eyes increase their sensitivity to low levels of illumination. Rhodopsin (visual purple) is the substance in the rods responsible for light sensitivity. The degree of dark adaptation increases as the amount of visual purple in the rods increases through biochemical reaction. Each person adapts to darkness in varying degrees and at different rates. For example, for the person viewing in a darkened movie theater, the eye adapts quickly to the prevailing level of illumination. However, compared to the light level of a moonless night, the light level within the movie theater is high. Another example is that a person requires less time to adapt to complete darkness after viewing in a darkened theater than after viewing in a lighted hangar, the lower the starting level of illumination, the less time is required for adaptation.

8-31. Dark adaptation for optimal night-vision acuity approaches its maximum level in about 30 to 45 minutes under minimal lighting conditions.

If the eyes are exposed to a bright light after dark adaptation, their sensitivity is temporarily impaired. The degree of impairment depends on the intensity and duration of the exposure. Brief flashes from high-intensity, white (xenon) strobe lights, which are commonly used as anticollision lights on aircraft, have little effect on night vision. This is true because the energy pulses are of such short duration (milliseconds). Exposure to a flare or a searchlight longer than one second can seriously impair night vision. Depending on the brightness (intensity), duration of exposure, or repeated exposures, an aircrew member's recovery time to regain complete dark adaptation could take from several minutes to the full 45 minutes or longer.

8-32. Exposure to bright sunlight also has a cumulative and adverse effect on dark adaptation. Reflective surfaces—such as sand, snow, water, or man-made structures—intensify this condition. Exposure to intense sunlight for two to five hours decreases visual sensitivity for up to five hours. In addition, the rate of dark adaptation and the degree of night visual acuity decrease. These cumulative effects may persist for several days.

8-33. The retinal rods are least affected by the wavelength of a dim red light. Figure 8-11 compares rod and cone cell sensitivities. Because rods are stimulated by low ambient light levels, red lights do not significantly impair night vision if the proper techniques are used. To minimize the adverse effect of red lights on night vision, crew members should adjust the light intensity to the lowest usable level and view instruments for only a short time.

8-34. Illness also adversely affects dark adaptation. A fever and a feeling of unpleasantness are normally associated with illness. High body temperatures consume oxygen at a higher-than-normal rate. This oxygen depletion may induce hypoxia and degrade night vision. In addition, the unpleasant feeling that is associated with sickness is distracting and may restrict the aircrew member's ability to concentrate on flight duties and responsibilities.

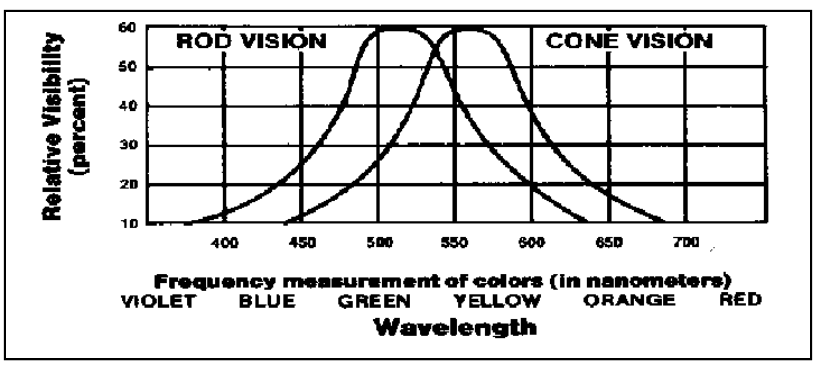

Figure 8-11. Photopic (Cone) and Scotopic (Rod) Sensitivity to Various Colors

NIGHT-VISION PROTECTION

8-35. Aircrew members should attain maximum dark adaptation in the minimal possible time. In addition, aircrew members must protect themselves against the loss of night vision. There are several methods for accomplishing these requirements.

PROTECTIVE EQUIPMENT

Sunglasses

8-36. When exposed to bright sunlight for prolonged periods, aircrew members should wear military-issued, neutral-density sunglasses (ND-15) or equivalent filter lenses when anticipating a night flight. This precaution minimizes the negative effects of sunlight (solar glare) on rhodopsin production, which maximizes the rate of dark adaptation and improves night vision sensitivity and acuity.

Red-Lens Goggles

8-37. Aircrew members, if possible, should wear approved red-lens goggles or view under red lighting before executing night-flying operations to achieve complete dark adaptation. This procedure allows aircrew members to begin dark adaptation in an artificially illuminated room before flight. Red lighting and red-lens goggles do not significantly interfere with the production of rhodopsin to stimulate the effectiveness of the rods for night vision. Red lighting and red-lens goggles decrease the possibility of undesirable effects from accidental exposure to bright lights; this is especially true when aviators are going from the briefing room to the flight line. Exposure to a bright-light source, however, lengthens the time for aircrew members wearing red-lens goggles to achieve dark adaptation. If the light source is high enough in intensity and duration of exposure is prolonged when viewing with red-lens goggles, aircrew members will not achieve complete dark adaptation. Red-lens goggles or red illumination does reduce dark adaptation time and may preserve up to 90 percent of the dark adaptation in both eyes. Aircrew members will not use red lighting or red-lens goggles when viewing inside or outside of the aircraft during flight. Red lighting is a longer nanometer, which is very fatiguing to the eyes. In addition, for aircrew members viewing under red lighting, the reds and browns found on nontactical maps not constructed for red-light use will bleach out.

Supplemental Oxygen Equipment

8-38. When flying at or above 4,000 feet pressure altitude, aircrews should use pressure-altitude supplemental oxygen if available. Adverse effects upon night vision set in at 4,000 feet pressure altitude. Effective night vision depends on the optimal function and sensitivity of the retinal rods. Lack of oxygen (hypoxia) significantly reduces rod sensitivity, increases the time required for dark adaptation, and decreases night vision. AR 95-1 describes the requirements of supplemental oxygen use related to pressure altitudes.

PROTECTIVE MEASURES

Cockpit Light Adjustment

8-39. Instrument, cockpit, and rear cargo area overhead lights (if applicable) should be adjusted to the lowest readable level that allows instruments, charts, and maps to be interpreted without prolonged staring or exposure. Although blue-green lighting at low intensities can also be used in cockpits without significantly disrupting unaided night vision and dark adaptation, items printed in blue-green may wash out. The use of blue-green lighting, however, has several benefits. Blue-green light falls naturally on the retinal wall and allows the eye to focus easily on maps, approach plates, and instruments; blue-green lighting results in less eye fatigue. In addition, the intensity necessary for blue-green lighting is less than that for red lighting and results in a decreased infrared signature as well as less glare. When blue-green lighting is used properly, the decrease in light intensity and the ease of focusing make it more effective for night vision.

Exterior Light Adjustment

8-40. Exterior lights should be dimmed or turned off if possible and the mission permits. Aviators should consult command policy for local procedures.

Light-Flash Compensation

8-41. Pilots should turn the aircraft away from the light source if a flash of high-intensity light is expected from a specific direction. The aircraft should also be maneuvered away from flares. When flares are illuminating the viewing area or are inadvertently ignited nearby, the pilot should maneuver to a position along the periphery of the illuminated area. The aircraft should be turned so that vision is directed away from the light source. This procedure minimizes exposure to the light source. When lightning or other unexpected conditions occur, crew members can preserve their dark adaptation by covering or closing one eye while using the other eye to observe. When the light source is no longer present, the eye that was covered provides the night-vision capability required for flight. The time spent expending ordnance should be limited. Minimizing this time decreases the effect of flash from aerial weapon systems and keeps the light level low. When firing automatic weapons, crew members should use short bursts of fire. If a direct view of the light source cannot be avoided, cover or close one eye. Remember that dark adaptation occurs independently in each eye. Depth perception will be severely degraded or lost, however, because both eyes are no longer completely dark adapted.

NIGHT-VISION TECHNIQUES

8-42. The human eye functions less efficiently at reduced ambient light levels. This reduction limits an aircrew member's visual acuity. Normal color vision decreases and finally disappears as the cones become inactive and the rods begin to function. Tower beacons, runway lights, or other colored lights can still be identified if the light is of sufficient intensity to activate the cones. Normal central daylight vision also decreases because of the night blind spot that develops in low illumination or dark viewing conditions. Therefore, the proper techniques for night-vision viewing must be used to overcome the reduced visual acuity at lower light levels.

OFF-CENTER VISION

8-43. Viewing an object with central vision during daylight poses no limitation. If this same technique is used at night, however, the object may not be seen. This is due to the night blind spot that exists under low light illumination. To compensate for this limitation, off-center vision must be used. Figure 8-12 illustrates the off-center vision technique. With this technique, crew members view an object by looking 10 degrees above, below, or to either side rather than directly at the object. Thus, the eyes can maintain visual contact with an object via peripheral vision. Aircrew members should avoid viewing objects for either too short or too long a time.

8-44. Rapid head or eye movements and fixations decrease the integrating capability of the dark-adapted eye. A steady fixation lasting one-half to one second achieves the maximum sensitivity.

8-45. An object viewed longer than two to three seconds tends to bleach out and become one solid tone. Therefore, the object can no longer be seen. This creates a potentially unsafe operating condition. The aircrew member must be aware of the phenomenon and avoid viewing an object longer than two to three seconds. By shifting the eyes from one off-center point to another, the aircrew member can see the object in the peripheral field of vision.

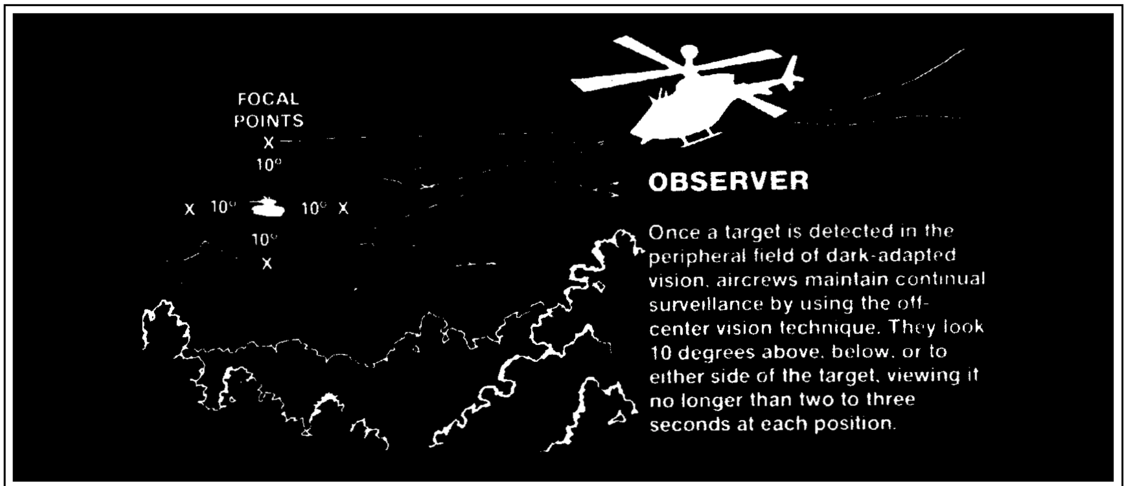

Figure 8-12. Off-Center Vision Technique

SCANNING

8-46. During daylight, objects can be perceived at a great distance with good detail. At night, the range is limited and detail is poor. Objects along the flight path can be more readily identified at night when aircrew members use the proper techniques to scan the terrain. To scan effectively, aircrew members look from right to left or left to right. They should begin scanning at the greatest distance at which an object can be perceived (top) and move inward toward the position of the aircraft (bottom). Figure 8-13 shows this scanning pattern. Because the light-sensitive elements of the retina are unable to perceive images that are in motion, a stop-turn-stop-turn motion should be used. For each stop, an area about 30 degrees wide should be scanned. This viewing angle will include an area about 250 meters wide at a distance of 500 meters. The duration of each stop is based on the degree of detail that is required, but no stop should last more than two or three seconds. When moving from one viewing point to the next, aircrew members should overlap the previous field of view by 10 degrees. This scanning technique allows greater clarity in observing the periphery. Other scanning techniques, as illustrated in Figure 8-14, may be developed to fit the situation.

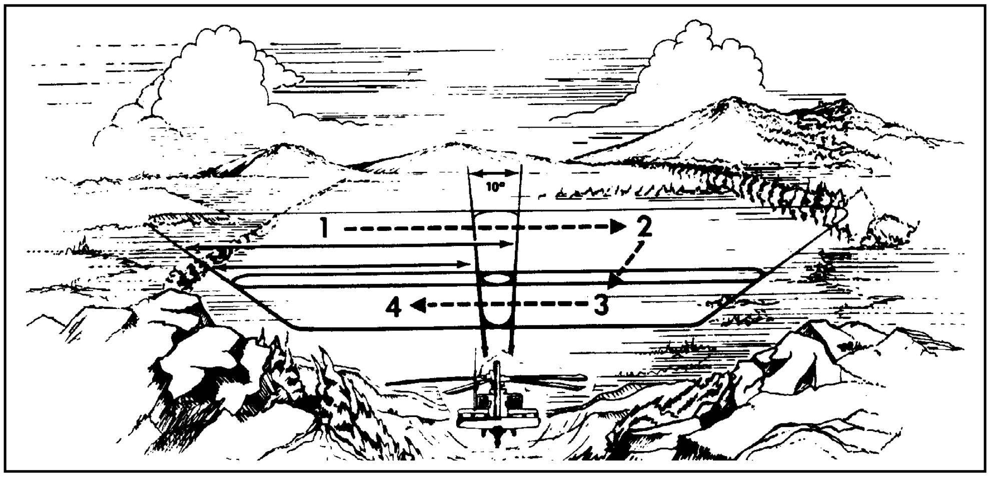

Figure 8-13. Scanning Pattern

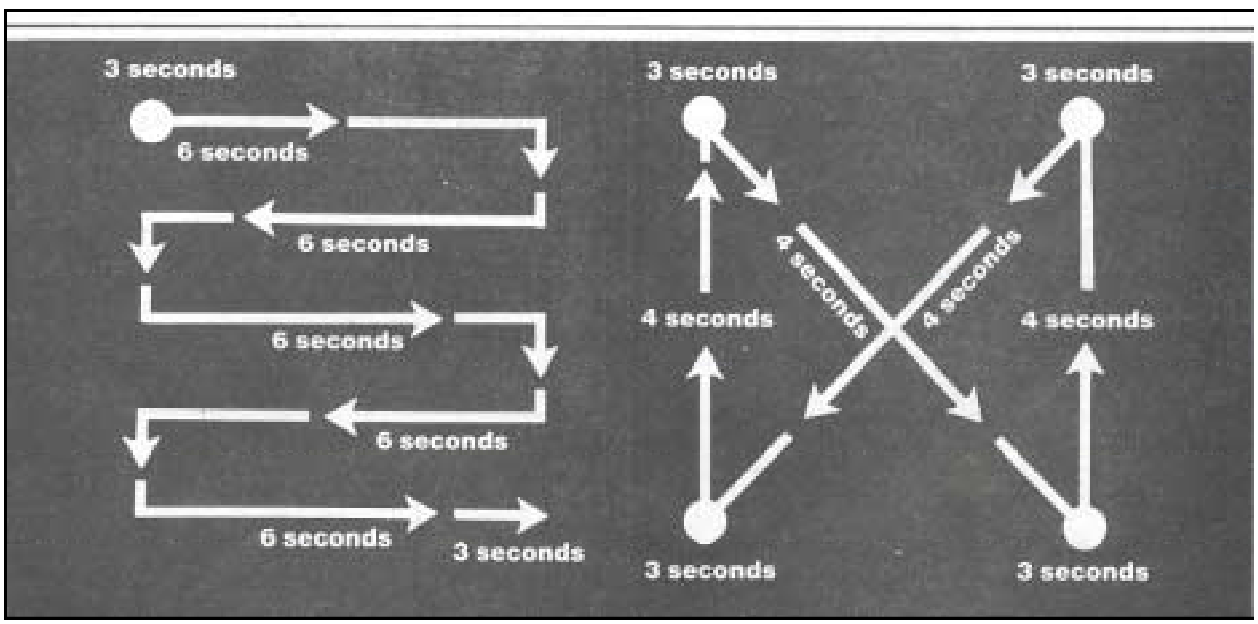

Figure 8-14. Typical Scanning Techniques

SHAPES OR SILHOUETTES

8-47. Because visual acuity is reduced at night, objects must be identified by their shapes or silhouettes. To use this technique, the aircrew member must be familiar with the architectural design of structures in the area covered by the mission. A silhouette of a building with a high roof and steeple can easily by recognized as a church in the United States. However, religious buildings in other parts of the world may have low-pitched roofs with no distinguishing features, to include cylinder-shaped structures. For example, the cylinder-shaped structures attached to Muslim mosques (religious temples), called minarets, are similar in shape to the silos attached to barns in the United States. Features depicted on the map will also aid in recognizing silhouettes.

DISTANCE ESTIMATION AND DEPTH PERCEPTION

8-48. The cues to distance estimation and depth perception are easy to recognize when aircrew members use central vision under good illumination. As light levels decrease, their ability to judge distance accurately degrades and their eyes are vulnerable to illusions. Aircrew members can better judge distance at night if they understand the mechanisms of visual cues related to distance estimation and depth perception. Distance can be estimated by using individual cues or by using a variety of cues. Aircrew members normally use subconscious factors to determine distance. They can more accurately estimate distance if they understand those factors and then learn to look for or be aware of other distance cues. These cues to distance or depth perception may be monocular or binocular.

BINOCULAR CUES

8-49. Binocular cues depend on the slightly different view each eye has of an object. Thus, binocular perception is of value only when the object is close enough to make a perceptible difference in the viewing angle of both eyes. In the flight environment, most distances outside the cockpit are so great that the binocular cues are of little, if any, value. In addition, binocular cues operate on a more subconscious level than do monocular cues. Study and training will not greatly improve them; therefore, they are not covered in this publication.

MONOCULAR CUES

8-50. Several monocular cues aid in distance estimation and depth perception. These cues are geometric perspective, motion parallax, retinal image size, and aerial perspective. They can be remembered by the acronym GRAM.

Geometric Perspective

8-51. An object appears to have a different shape when crew members view it at varying distances and from different angles. The types of geometric perspective include linear perspective, apparent foreshortening, and vertical position in the field. Figure 8-15 illustrates these. They can be remembered by the acronym LAV.

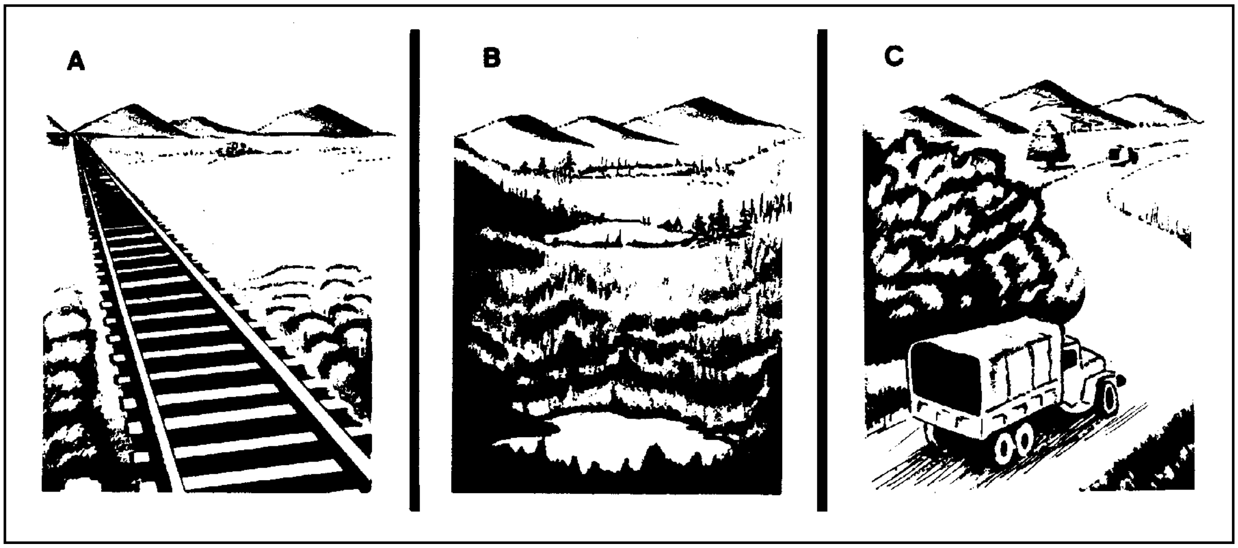

Figure 8-15. Geometric Perspective

8-52. **Linear Perspective.** Parallel lines, such as railroad tracks, tend to converge as distance from the observer increases. This is illustrated in part A of Figure 8-15.

8-53. **Apparent Foreshortening.** The true shape of an object or terrain feature appears elliptical (oval and narrowed appearance) when viewed from a distance when aircrew members are flying at both higher and lower altitudes. As the distance to the object or terrain feature decreases, the apparent perspective changes to its true shape or form. When flying at lower altitudes and viewing at greater distances, aircrew members may not view objects clearly. If the mission permits, pilots should gain altitude and decrease distance from the viewing area to compensate for this perspective. That is, once the aircraft increases in altitude and distance between the aircraft and the viewing area decreases, the viewing field widens and enlarges so that objects within that field of view become apparent. Part B of Figure 8-15 illustrates how the shape of a body of water changes when viewed at different distances while the aircraft maintains the same altitude.

8-54. **Vertical Position in the Field.** Objects or terrain features that are at greater distances from the observer appear higher on the horizon than do those that are closer to the observer. In part C of Figure 8-15, the higher vehicle appears to be closer to the top and is judged as being at a greater distance from the observer. Before flight, aircrew members should already be familiar with the actual sizes, heights, or altitudes of known objects or terrain features within and around the planned flight route. If the situation and time permit, aircrew members can reference published information to verify actual sizes, heights of objects, and terrain features within their flight path. In addition, the aircrew members should cross-reference their aircraft's altitude indicator to confirm that actual aircraft altitude is adequate to safely negotiate the object or terrain feature without prematurely changing the aircraft's heading, altitude, or attitude or a combination of these.

Motion Parallax

8-55. This is often considered the most important cue to depth perception. Motion parallax refers to the apparent, relative motion of stationary objects as viewed by an observer who is moving across the landscape. Near objects appear to move past or opposite the path of motion; far objects seem to move in the direction of motion or remain fixed. The rate of apparent movement depends on the distance that the observer is from the objects. Objects near the aircraft appear to move rapidly, while distant objects appear to be almost stationary. Thus, objects that appear to be moving rapidly are judged to be near while those moving slowly are judged to be at a greater distance. Motion parallax can be apparent during flight. One example is an aircraft flying at 5,000 feet AGL. At that altitude, the terrain off in the distance appears to be stationary. The terrain immediately below and to either side of the aircraft may appear to be moving slowly, depending on the forward airspeed of the aircraft. The opposite is true when an aircraft descends to 80 feet AHO with a forward airspeed of 120 knots. The terrain and objects in the horizon appear to move at a faster rate, while the terrain and objects underneath and to either side of the aircraft appear to pass by at a high rate of speed.

Retinal Image Size

8-56. **Distance Estimation.** An image focused on the retina is perceived by the brain to be of a given size. The factors that aid in determining distance using the retinal image are known size of objects, increasing and decreasing size of objects, terrestrial association, and overlapping contours or interposition of objects. These factors can be remembered by the acronym KITO.

8-57. **Known Size of Objects.** The nearer an object is to the observer, the larger its retinal image. By experience, the brain learns to estimate the distance of familiar objects by the size of their retinal image. Figure 8-16 shows how this method is used. A structure projects a specific angle on the retina, based on its distance from the observer. If the angle is small, the observer judges the structure to be at a great distance. A larger angle indicates to the observer that the structure is close. To use this cue, the observer must know the actual size of the object and have prior visual experience with it. If no experience exists, aircrew members determine the distance to an object primarily by motion parallax.

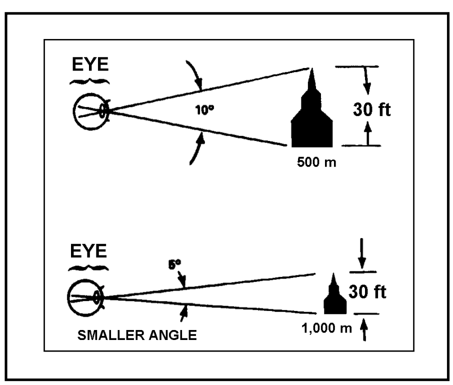

Figure 8-16. Known Size of Object Used to Determine Distance

8-58. **Increasing or Decreasing Size of Objects.** If the retinal image of an object increases in size, the object is moving closer to the observer. If the retinal image decreases, the object is moving farther away. If the retinal image is constant, the object is at a fixed distance.

8-59. **Terrestrial Association.** Comparison of one object, such as an airfield, with another object of known size, such as a helicopter, will help to determine the relative size and apparent distance of the object from the observer. Figure 8-17 shows that that objects ordinarily associated together are judged to be at about the same distance. For example, a helicopter that is observed near an airport is judged to be in the traffic pattern and, therefore, at about the same distance as the airfield.

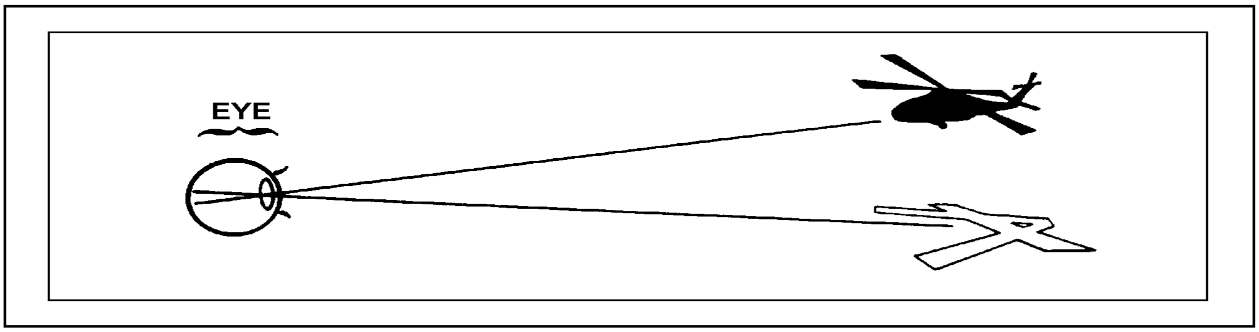

Figure 8-17. Terrestrial Association of Objects Used to Determine Distance

8-60. **Overlapping Contours or Interposition of Objects.** When objects overlap, the overlapped object is farther away. For example, an object partly concealed by another object is behind the object that is concealing it. Aircrew members must be especially conscious of this cue when making an approach for landing at night. Lights disappearing or flickering in the landing area should be treated as barriers, and the flight path should be adjusted accordingly. Figure 8-18 illustrates overlapping contour.

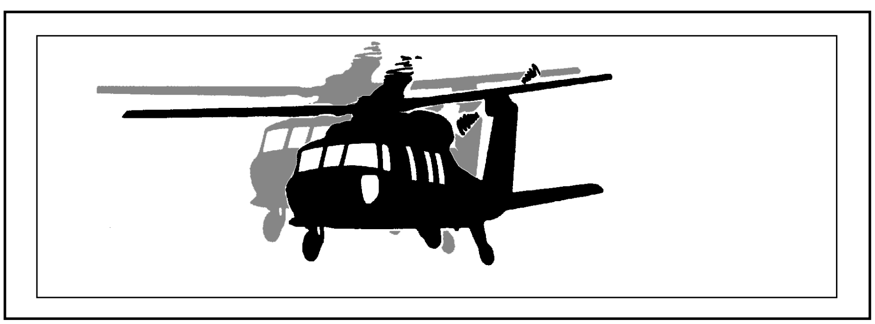

Figure 8-18. Overlapping Contour Used to Determine Distance

Aerial Perspective

8-61. The clarity of an object and the shadow cast by it are perceived by the brain and are cues for estimating distance. To determine distance with these aerial perspectives, aircrew members use the factors discussed below.

8-62. **Fading of Colors or Shades.** Objects viewed through haze, fog, or smoke are seen less distinctly and appear to be at a greater distance than they actually are. If atmospheric transmission of light is unrestricted, an object is seen more distinctly and appears to be closer than it actually is. For example, the cargo helicopter in Figure 8-19 is larger than the observation helicopter, but because of the difference in viewing distance and size, they both project the same angle on the observer's retina. From this cue alone, assuming the observer has no previous experience with their appearance, both helicopters appear to be the same size. However, if the cargo helicopter is known to be a larger aircraft but is seen less distinctly because of visibility restrictions, it would be judged to be farther away and larger than the observation helicopter. Another example is that aircrew members may not be able to distinguish green from red anticollision lights and the actual interval between aircraft when an additional aircraft is operating at a distance. Both lights may appear to be white, and in addition, they may even blend in with the surrounding foreground.

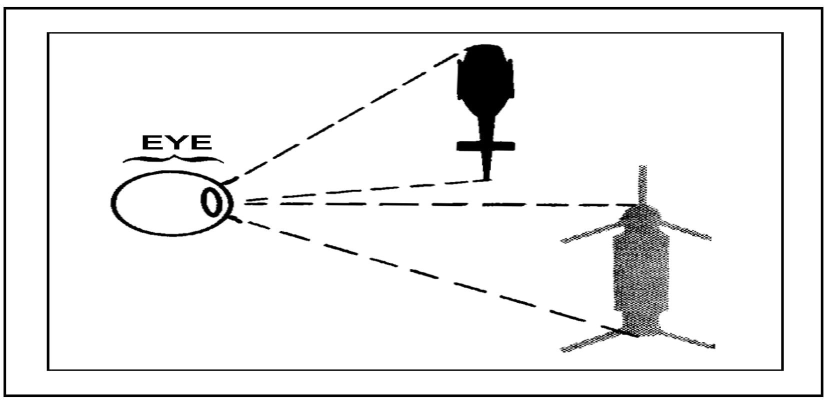

Figure 8-19. Fading Color or Shade Used to Determine Distance

8-63. **Loss of Detail or Texture.** The farther from an object that an observer is, the less apparent discrete details become. For example, a cornfield at a distance becomes a solid color, leaves and branches of a tree become a solid mass, and objects are judged to be at a great distance. With the aircraft operating on the ground, crew members view the grass or gravel immediately below, in front of, or alongside the aircraft. As the aircraft slowly ascends, they maintain a view of that grass or gravel. Aircrew members will notice that, as the aircraft ascends, the clarity and detail of the grass is fading and eventually blends in with the terrain as a whole, causing the viewer not to be able to identify blades of grass or gravel. Environmental factors increase the effects of degraded texture and detail of objects throughout the visual field. This loss of detail, in turn, severely decreases depth perception and is a contributing factor in relation to aircrew members' misjudgments of what is seen or not seen and the occurrence of incidents related to those misjudgments.

8-64. **Position of Light Source and Direction of Shadow.** Every object will cast a shadow if there is a source of light. The direction in which the shadow is cast depends on the position of the light source. If the shadow is cast toward the observer, the object is closer than the light source to the observer. Figure 8-20 shows how light and shadow help determine distance.

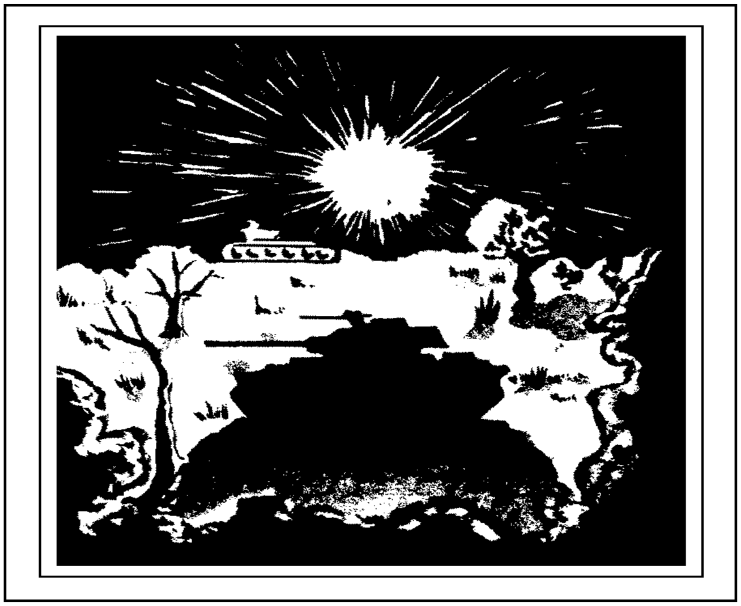

Figure 8-20. Position of Light Source and Direction of Shadow Used to Determine Distance

VISUAL ILLUSIONS

8-65. As visual information decreases, the probability of spatial disorientation increases. Reduced visual references also create several illusions that can cause spatial disorientation. Chapter 9 covers these illusions in more detail.

METEOROLOGICAL CONDITIONS AND NIGHT VISION

8-66. Although a flight may begin with clear skies and unrestricted visibility, meteorological conditions may deteriorate during flight. Because of reduced vision at night, clouds can appear gradually and easily go undetected by aircrew members. The aircraft may even enter the clouds inadvertently and without warning. At low altitudes, fog and haze can be encountered. Visibility can deteriorate gradually or suddenly. Because it is difficult to detect adverse weather at night, crew members should be constantly aware of changing weather conditions. The following conditions are indicators of adverse weather at night.

8-67. The ambient light level is gradually reduced as cloud coverage increases. Visual acuity and contrast of terrain features are lost, possibly to complete obscurity. If this condition should occur, pilots should initiate inadvertent IMC procedures. Aircrew members must follow their local SOPs and command directives and realize that inadvertent IMC at night is one of the leading causes of Class A mishaps.

8-68. If the moon and stars cannot be seen, clouds are present. The less visible the stars and moon, the heavier the cloud coverage.

8-69. Clouds obscuring the illumination of the moon create shadows. These shadows can be detected by observing the varying levels of ambient light along the flight route.

8-70. The halo effect, which is observed around ground lights, indicates the presence of moisture and possible ground fog. As the fog and moisture increase, the intensity of the lights will decrease. This same effect is apparent during flight. As moisture increases, the light that is emitted from the aircraft is reflected back upon the aircraft. When this reflection occurs, it is possible to misjudge terrain features, man-made structures, and the actual position, heading, and altitude of other aircraft including the layout and height of the terrain below.

8-71. The presence of fog over water surfaces indicates that the temperature and dew point are equal. It also indicates that fog may soon form over ground areas.

SELF-IMPOSED STRESS AND VISION

8-72. The normal aviation stress that aircrew members experience in flight, such as altitude, may not be controllable and may affect mission performance somewhat. In addition, those involved in aviation must cope with self-imposed stress. Unlike aviation stress, aircrew members themselves can control self-imposed stress. The factors that cause this stress are drugs, exhaustion, alcohol, tobacco, and hypoglycemia and nutrition. These factors, shown in Figure 8-21, can be remembered by the acronym DEATH (refer to AR 40-8).

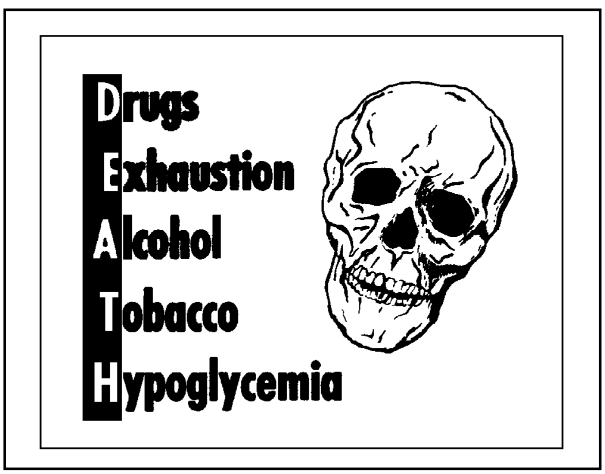

Figure 8-21. Self-Imposed Stress Factors

DRUGS

8-73. Adverse side effects associated with drug use are illness and degradation in motor skills, awareness level, and reaction time. Aircrew members who become ill should consult the flight surgeon. Crew members should avoid self-medicating; it is unauthorized for flight personnel. AR 40-8 contains restrictions on drug use while on flight status.

EXHAUSTION

8-74. Tiredness reduces mental alertness. In situations that require immediate reaction, exhaustion causes aircrew members to respond more slowly. They tend to concentrate on one aspect of a situation without considering the total environment. Rather than use proper scanning techniques, they are prone to stare, which may cause incidents. Good physical conditioning should decrease fatigue and improve night-scanning efficiency. However, excessive exercise in a given day can lead to increased fatigue. Night flying is more stressful than day flying. Aircrew members should follow prescribed crew-rest policies. Multiple factors cause exhaustion; normally, exhaustion does not set in from one factor alone. Contributing factors associated with exhaustion include poor diet habits, lack of rest, poor sleeping patterns, poor physical condition, an inadequate exercise routine, environmental factors, dehydration, and combat stress. In combination, these can create exhaustion. Common side effects associated with exhaustion include altered levels of concentration, awareness, and attentiveness; increased drowsiness (nodding off or falling asleep); and ineffective night-vision viewing techniques (staring, rather than scanning).

ALCOHOL

8-75. Alcohol causes a person to become uncoordinated and impairs judgment. It hinders the aircrew member’s ability to view properly. The aircrew member is likely to stare at objects and neglect proper scanning techniques, particularly at night. In addition, as is indicated by the physiological response of the body to a hangover, the effects of alcohol are long lasting. Alcohol induces histotoxic hypoxia, which is the poisoning of the bloodstream, interfering with the use of oxygen by body tissues. One ounce of alcohol in the bloodstream at sea level places an individual at 2,000 feet physiologically. Every ounce of alcohol in the bloodstream at sea level increases the body’s physiological altitude. For example, an individual who consumes three ounces of alcohol at sea level and is then placed at 4,000 feet actual pressure altitude has a physiological altitude of 10,000 feet. Now, combined with the histotoxic hypoxia effects is hypoxic hypoxia. This individual’s time of useful consciousness is severely impaired. If the flight is longer than 60 minutes, the individual may become unconscious and may even die from lack of oxygen, by textbook definition (AR 95-1, altitude restrictions without the use of supplemental oxygen). The guidance for performing or resuming aircrew member duties when alcohol is involved is 12 hours after the last consumed alcohol with no residual physiological effects present. Aircrew member duties include preflight and postflight actions, to include maintenance; they are not limited to actual operation of the aircraft or flight. Detrimental effects associated with the consumption of alcohol include poor judgment, decision making, perception, reaction time, coordination, and scanning techniques (tendency to stare at objects).

TOBACCO

8-76. Of all self-imposed stresses, cigarette smoking decreases visual sensitivity at night the most. The hemoglobin of the red blood cells has a 200 to 300 times greater affinity for carbon monoxide than for oxygen. That is, the hemoglobin accepts the carbon monoxide far more rapidly than it will accept oxygen. During normal pulmonary perfusion (gas exchange within the lungs), carbon dioxide is released from the bloodstream when an individual exhales. When an individual inhales, the normal action is that oxygen is absorbed into the blood (hemoglobin of the red blood cell); thus, normal levels of oxygen and other gas levels are being maintained within the bloodstream. Smoking increases CO, which in turn, reduces the capacity of the blood to carry oxygen. The hypoxia that results from this increase in carbon monoxide is hypemic hypoxia, which negatively affects the aircrew member's peripheral vision and dark adaptation. If, for example, an individual smokes 3 cigarettes in rapid succession or 20 to 40 cigarettes within a 24-hour period, the carbon monoxide content of the blood is raised 8 to 10 percent. The physiological effect at ground level is the same as flying at 5,000 feet. More importantly, the smoker has lost about 20 percent of night-vision capability at sea level. Table 8-1 compares reduced night vision at varying altitudes for smokers and nonsmokers.

Table 8-1. Percentage Reduction of Night Vision at Varying Altitudes for Smokers and Nonsmokers

Altitude (feet)	**Nonsmoker (%)**	**Smoker (%)**
4,000	Sea Level	20
6,000	5	25
10,000	20	40
14,000	35	55
16,000	40	50

HYPOGLYCEMIA AND NUTRITIONAL DEFICIENCY

8-77. Aviation personnel should avoid missing or postponing meals. They should also avoid supplementing primary meals with fast sugars (for example, sodas and candy bars). These foods and beverages can cause low blood-sugar levels. Low blood-sugar levels may result in hunger pangs, distraction, a breakdown in habit patterns, a shortened attention span, and other physiological changes. Supplementing with fast sugars as the primary diet will, on average, sustain the individual for up to 30 to 45 minutes. The negative effects will then increase in intensity. Not only can an improper diet cause hypoglycemia, but a diet that is deficient in Vitamin A can also impair night vision. Vitamin A is an essential element in the buildup of rhodopsin (visual purple) for stimulation of the rod cells. Without this buildup of rhodopsin, night vision is severely degraded. An adequate intake of Vitamin A—through a balanced diet that includes such foods as eggs, butter, cheese, liver, carrots, and most green vegetables—will help maintain visual acuity. Aircrew members must consult a flight surgeon before consuming Vitamin A supplements that are not organic to the foods noted above.

NERVE AGENTS AND NIGHT VISION

8-78. Night vision is adversely affected when the eyes are exposed to minute amounts of nerve agents. When direct contact occurs, the pupils constrict (miosis) and do not dilate in low ambient light. The available automatic chemical alarms are not sensitive enough to detect the low concentrations of nerve-agent vapor that can cause miosis.

8-79. The exposure time required to cause miosis depends on agent concentration. Miosis may occur gradually as eyes are exposed to low concentrations over a long period. On the other hand, exposure to a high concentration can cause miosis during the few seconds it takes to put on a protective mask. Repeated exposure over a period of days is cumulative.

8-80. The symptoms of miosis range from minimal to severe, depending on the dosage to the eye. Severe miosis, with the resulting reduced ability to see in low ambient light, persists for about 48 hours after onset. The pupil gradually returns to normal over several days. Full recovery may take up to 20 days. Repeated exposure within the affected time will be cumulative.

8-81. The onset of miosis is insidious because it is not always immediately painful. Miotic subjects may not recognize their condition, even when they carry out tasks requiring vision in low ambient light. After an attack by nerve agents, especially the more persistent types, commanders should assume that some loss of night vision has occurred among personnel otherwise fit for duty and consider grounding the aircrew members until they fully recover. All exposed aircrew members and aircraft-related maintenance personnel must consult medical personnel and the flight surgeon immediately after exposure.

FLIGHT HAZARDS

8-82. Solar glare, bird strikes, nuclear flash, and lasers are possible hazards that an aircrew member may encounter during low-level flight.

SOLAR GLARE

8-83. Glare from direct, reflected, or scattered sunlight causes discomfort and reduces visual acuity. To reduce or eliminate discomfort, every aircrew member should wear, lowered, the tinted visor or wear issued ND-15 sunglasses with the clear visor. Day blindness can occur in areas of extreme solar glare (in snow, over water, or in desert environments).

BIRD STRIKES

8-84. This hazard can occur during the day or at night during low-level flight. Cockpit windshields are designed to withstand impacts, but the potential exists for shattering. According to the FAA, if an aircraft traveling at an airspeed equivalent to a 120-mile-per-hour ground speed strikes a two-pound seagull, the force exerted would be equal to 4,800 pounds. Some antiaircraft rounds exert less force than that. Therefore, the clear visor for night flights and the tinted visor for day flights (if the viewing environment warrants) should be worn (lowered) by aircrew members. These visors would not only protect their eyes from the remains of the bird but also, more importantly, from the glass fragments of the windshield.

NUCLEAR FLASH

8-85. A fireball from a nuclear explosion can produce flash blindness and cause retinal burns. By day, the optical blink reflex should prevent retinal burns from distances where survival is possible. At night, when the pupil is dilated, retinal burns are possible and indirect flash blindness can deprive aircrew members of all useful vision for periods exceeding one minute. No practical protection against nuclear flash has been developed.

LASERS

8-86. Mobile military lasers currently work by converting electrical and chemical energy into light. This light can be either continuously emitted or collected over time and suddenly released. A laser is light amplified by a stimulated emission of radiation through one prism or a series of multiple prisms, which increases the laser-light frequency and intensity. The beam of light produced is usually less than one inch in diameter; the beam may or may not be visible to the naked eye (ultraviolet, infrared, and thermal lasers). Laser range finders and target designators, except for thermal infrared lasers, operate by accumulating and suddenly releasing light energy in the form of a crystal rod. This rod is about the size of a cigarette. The laser pulse is controlled by an electrical signal that turns the laser on and off. Laser pulses travel at the speed of light—300,000 kilometers per second. During a laser pulse, when the laser is actually emitting light, the power output is an average of about 3 megawatts (3 million watts) along a narrow beam. About 90 percent of the energy emitted is contained in this narrow beam. This characteristic of lasers makes them useful as range finders and target designators but also makes them dangerous to human eyes. Lasers can damage eyes from a considerable distance although the diameter of the laser beam widens as distance increases, thus reducing its energy level. Distance is the best protection, but if that is not possible, then protective ballistic and laser protective eyewear goggles or visors may offer limited protection. These BLPs are laser-frequency specific. Aircrew members need to identify what type of laser-frequency threat that they may encounter to receive the correct type of BLP eyewear from their unit ALSE technician. Smoke, fog, and dust weaken laser light. A useful rule is that “if you see the target through smoke, laser energy can hit the target and the laser energy can also strike your eyes.” In daylight, even visual-light lasers are “invisible” unless there is smoke, mist, or fog in the air. The four major classes of directed-energy systems are high-energy lasers, low-energy lasers, radio-frequency lasers, and particle-beam lasers. The following is a breakdown of all four classifications.

Class 1

8-87. Class 1 laser devices do not emit hazardous laser radiation under any operating or viewing condition. These lasers include those that are fully enclosed; for example, PAQ-4A/B/C infrared aiming lights and many of the laser marksmanship trainers.

Class 2

8-88. Class 2 laser devices are usually continuous-wave visible laser devices. Precautions are required to prevent staring into the direct beam. Momentary exposure (greater than 0.25 second) is not considered hazardous; for example, current (updated) laser pointers, construction lasers, and alignment lasers.

Class 3a

8-89. Class 3a lasers normally are not hazardous unless crew members view them with magnifying optics from within the beam. These type of lasers include visible and invisible frequency lasers; for example, a miniature eye-safe laser infrared observation set, commonly known as melios.

Class 3b

8-90. Class 3b lasers are potentially hazardous if the direct or specularly reflected beam is viewed by unprotected eyes. Care is required to prevent intrabeam (within the beam) viewing and to control specular (such as from mirrors or still water) reflections. This type of laser includes many range finders and the AIM-1, GCP-1, and AN/PEQ-2A laser pointers.

Class 4

8-91. Class 4 lasers are pulsed, visible, and near-infrared lasers that can produce diffuse reflections, fire, and skin hazards (especially to the eyes). These lasers have an average output of 500 milliwatts or more. Safety precautions generally consist of using door interlocks to protect personnel entering the laser facility from exposure, using baffles to terminate primary and secondary beams, and wearing protective eyewear and clothing. Aircrew members exposed to this type of laser inadvertently or without prior warning would receive serious retinal burns within tenths of a second exposure time if their eyes were unprotected. For military operations during peacetime, these lasers are normally operated only on cleared, approved laser ranges or while personnel are using appropriate eye/skin protection. However, actual opposing forces may intentionally expose crew members to deplete the aircrew's fighting capability. This class of laser includes industrial welders and target-designator lasers.

PROTECTIVE MEASURES

BUILT-IN PROTECTIVE MEASURES

8-92. Filters can stop laser light. These filters are pieces of glass or plastic that absorb or reflect light of a given color (wavelength). Sunglasses are especially created to filter visual light. An infrared or ultraviolet laser will pass through these types of glass and still damage the eyes. Presently, the Army has protective eyewear that will assist in preventing ocular injuries from certain types of lasers; for example, B-LPs.

PASSIVE PROTECTIVE MEASURES

8-93. Passive protective measures also help protect from laser injury. Passive protective measures consist of—

- Taking cover.
- Getting out of the path of the laser beam.
- Using available protective gear.
- Keeping all exposed skin areas covered to prevent skin burns.

ACTIVE PROTECTIVE MEASURES

8-94. Active protective measures consist of—

- Using countermeasures, as taught or directed by the unit commander.
- Applying evasive action.
- Scanning the battlefield with one eye or monocular optics.
- Minimizing the use of binoculars in areas where lasers may be in use.

Crew members should use hardened optical systems and built-in or clip-on filters (BLPs) and deploy smoke, if capable. FM 4-02.50(8-50) contains information regarding prevention and medical management of laser injuries.

PRINCIPLES OF PROPER VISION

8-95. Aircrew members must completely understand the function of the eye and the techniques that they can employ to overcome visual limitations. It is usually not the lack of visual acuity that causes problems for aircrew members but rather a lack of understanding of "how to see" properly. In summary, the principles of proper vision require that aircrew members—

- Understand the types of vision and the limitations of each and that visual acuity will normally be lost under low levels of illumination.
- If corrective lens are prescribed to aircrew members, they must use corrective lens (glasses) in all modes of flight to include night-aided (ANVIS, night-vision devices/goggle systems) flight.
- Be aware that it will take 30 to 45 minutes for the average individual's eyes to reach maximum dark adaptation.
- Remember to use off-center vision when viewing objects under reduced lighting conditions.
- Use supplemental oxygen, if available, on flights (especially night flights) at or above 4,000 feet pressure altitude.
- Avoid self-imposed stress.
- Protect night vision by avoiding bright lights once dark adaptation has been achieved.
- Scan constantly when viewing objects outside the cockpit, day or night.
- Know and understand the effects of nerve agents and take protective measures against laser injury.